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Emergence of regularities and symmetries from complex nuclei

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A challenge in studying complex many-body systems is to understand the remarkable regularities they sometimes exhibit and possibly relate these to the underlying symmetry of the system. Progress in this direction was initiated by the discovery of particular nuclei that undergo quantum phase transitions in their equilibrium shapes and the development of extremely simple, analytic descriptions of nuclei at the phase transitional point in terms of critical point symmetries (CPS). Recent results inspired by the concept of CPS will be presented. Experiments aimed at identifying empirical manifestations of CPS, previously constrained to a few select regions, will be presented, covering a wider range of the nuclear chart. New observables will be discussed which not only serve as effective order parameters for identifying phase transitional behavior, but also distinguish between first and second order phase transitions. Finally, very simple and general regularities in the predictions of not only CPS, but also in other standard models, will be presented. These suggest the presence of possible underlying symmetries in a wider range of structures not limited to the critical point. This research is supported by the DOE Office of Nuclear Physics under contract DE-AC02-06CH11357.